

EARLY WARNING SYSTEM FOR THE MEKONG RIVER

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Abstract: The Mekong River, one of the largest rivers in the world, is among the few rivers that are in almost their natural state, without interference from human influences. The floods of the river are among the major sources of the well being of the population, and the annual recurrence of the Monsoon floods is a benefit for the country. However, in some years the benefits are reversed: the floods of the river overflow the banks and inundate vast portions of the land for many weeks. Consequently, it is necessary to adjust human activities to the rhythm of the river. The best people can do is to try to anticipate the flood and to be prepared to live with the floods, both when the floods are beneficial and when they are harmful. This requires that the flood levels are forecasted sufficiently far ahead in time. However, a forecast is not sufficient: an efficient flood management system requires that the forecasting activity is augmented by actions. The sum of the actions to be taken to prepare a forecast and to make it to be of maximum benefit to the people is embodied in an efficient early warning system. A novel approach for obtaining such a system consists of direct interaction of international scientists and regional experts - as has been practiced in an experimental international expert meeting for the Mekong river.

Keywords: Mekong river, early warning, forecasting systems

INTRODUCTION

The Mekong river is one of the largest rivers in the World, which even today is in a near natural state. Plans for its development, mainly for hydropower and flood mitigation, had been prepared by the Mekong Commission, located in Bangkok, Thailand, but for political reasons these plans were not realized in the second half of the 20-th century. In the late 20-th century the emphasis shifted from the concept of maximizing hydropower production to the modern concept of "living with rivers", implying that the river is left as much as possible in its natural state. In April 1995 the four countries Cambodia, Laos, Thailand and Vietnam signed an Agreement on the Co-operation for the Sustainable Development of the Mekong River Basin according to the concept of living with the river. They stated their intention of close cooperation in the utilization, conservation and management of the Mekong water and related resources. To facilitate cooperation the Mekong Committee was reestablished as Mekong River Commission, with the Mekong River Commission Secretariat (MRCS) located in Phnom Penh, Cambodia. The MRCS is the technical and administrative arm of the MRC working with professional staff from the riparian countries and international experts. It oversees formulation and implementation of programs and projects and prepares strategic studies and basin wide plans for water resources management, agriculture, irrigation, watershed management and forestry, fisheries, river training works and navigation, and human resources development. Core programs implemented under the 1995 Mekong Agreement are the Water Utilization Program, the Basin Development Plan, as well as different Environment and Capacity Building Programs. Furthermore, it sets up data collection and information systems for the Mekong and analyses their results. It is responsible for international flood forecasting, remote sensing and mapping and environmental studies.

In summer of the year 2000 (and again in 2001) a particularly devastating flood occurred in the Lower Mekong Basin. It caused damage of US\$ 400 Million, and 800 fatalities, mainly children. A recurrence interval of 70 years was estimated for the flood level at Phnom Penh. In response, the MRC council, at its Annual Meeting in Pakse in October 2000, called for immediate action and charged the MRCS to develop plans for basin wide Flood Management and Mitigation (FMM) in the Mekong River Basin. The MRCS set up a task force, which produced, with the help of international experts, a strategy on flood management and mitigation (MRCS, 2001). The strategy was accepted by the MRC Council in fall of 2001, and is to be implemented by specific projects that are to be formulated in a process which has just begun.

Among the projects of the strategy that have the highest priority is the development of an improved early warning system. This task offered an opportunity to use a new approach of technology transfer from science to applications. An expert meeting was conducted in February 2002 (MRC, 2002). International scientists with considerable practical experience in the different aspects of flood warning, representing natural and social sciences, were invited to review the existing flood warning process, based on their experience in different countries, taking account of previous efforts. They produced a set of recommendations for improvement of the existing system, which will guide the planning of the future early warning system for the Mekong. As these principles might be of value also for other projects, the concept of the expert meeting and the recommendations as they apply to the Mekong will be presented. First, it is necessary to take a look at the Mekong river.

THE MEKONG

The Mekong is the longest river in Southeast Asia and drains a total catchment area of 795,000 km² of which 606,000 km² is in the Lower Mekong Basin and comprises almost all Laos and Cambodia, one third of Thailand (its North-eastern region and part of its Northern region), and one fifth of Vietnam (the Central Highlands and the Delta).

From its sources on the Tibetan Plateau at an elevation of 5,000 m, the Mekong flows in a southerly direction through southern China and, having touched Myanmar over a short stretch, it enters the Lower Mekong Basin, where it first forms the boundary between Laos and Thailand, before flowing into the delta, where Cambodia and Vietnam share its waters. Rice farming and fishery are the main staples to sustain the rapidly growing populations of these two countries. A map of the Mekong basin is shown in Fig. 1. (for details see Hori, 2000, Osborn, 2000)



Fig.1: The Lower Mekong Basin

The Lower Mekong Basin is situated in the tropical zone of the Northern Hemisphere. Its climate is influenced by the Southwest and Northeast monsoons. By mid-October in the North, and by late October in the South, the drier and cooler North-easterly wind starts to dominate the weather of the area and the dry season begins. It lasts from early November to mid-March.

When the intertropical convergence zone moves northward in mid-May the Southwest monsoon initiates the rainy season. By June a steady south-westerly airflow is established with regular, occasionally torrential local showers caused by convection or orographic lifting. In August and September tropical cyclones from the North Pacific Ocean and the South China Sea enter the area and produce long lasting heavy rainfall by interacting with the monsoon. During this period, flash floods in mountainous areas and inundation of fertile low land by bank overflow frequently occur in the delta, causing casualties and damage to property, agricultural land, crops, infrastructure, industry etc. The mean annual rainfall ranges from about 1000 mm in parts of North-east Thailand to more than 3000 mm in the mountainous border areas between Southern Laos and Viet Nam.

The average Mekong river runoff is about 475 000 million m³ per year which is equivalent to 600 mm depth of water over the entire basin. Increases and decreases of the Mekong river runoff are strongly correlated with the annual rainfall pattern in the lower Me-

kong basin, because although the upper Mekong basin has 26 per cent of the area, it contributes less than 20 per cent of the annual runoff. The level of the Mekong river starts to rise at the beginning of the South-west monsoon in May and reaches its peak in mid-August or early September in the upper reach, and in mid September or early October in the delta region. In the middle reach the discharge of the river is increased by the tributaries from Laos and from Thailand, where the rising river stages of the Mekong may lead to back up effects with resulting floods in the lower reaches of the tributaries.

Table 1 : *General Hydrology of the Mekong River*

| Gauging stations | Country | Drainage area x 10 ³ km ² | Maximum discharge (m ³ /sec) | Minimum discharge (m ³ /sec) | Average discharge (m ³ /sec) | Average runoff /year 10 ⁹ m ³ | Average annual sediment 10 ⁶ to |
|------------------|----------|---|---|---|---|---|--|
| Chiang Saen | Thailand | 189 | 23 500 (1966) | 548 (1969) | 2 730 (31 [*]) | 86 | 160 |
| Luang Prabang | Lao PDR | 268 | 25 200 (1966) | 652 (1956) | 3 837 (42 [*]) | 121 | |
| Vientiane | Lao PDR | 299 | 26 000 (1966) | 701 (1956) | 4 553 (79 [*]) | 144 | |
| Nong Khai | Thailand | 302 | 28 500 (1966) | 859 (1989) | 4 510 (25 [*]) | 142 | |
| Thakhek | Lao PDR | 373 | 33800 (2000) | 958 (1933) | 7 400 (68 [*]) | 233 | |
| Savannakhet | Lao PDR | 391 | 36 500 (1978) | 1 060 (1932/33) | 8 019 (68 [*]) | 253 | |
| Pakse | Lao PDR | 545 | 57 800 (1978) | 1 250 (1960) | 10 110 (68 [*]) | 319 | |
| Stung Treng | Cambodia | 635 | 65 700 (1939) | 1 250 (1960) | 13 380 (46 [*]) | 422 | |
| Kratie | Cambodia | 646 000 | 66 700 (1939) | | 13 970 (45 [*]) | 441 | |
| Phnom Penh | Cambodia | 663 000 | 49 700 (1961) | | 13 100 (14 [*]) | 413 | |

Note: * Number of years of records

Peak flows reach their maximum at Kratie. Below Kratie, the river overflows during extreme floods, and when the flood peak reaches Phnom Penh about 4 days later, the discharge is already somewhat reduced. At Phnom Penh, the Mekong divides into three parts, the Tonle Sap river, the Bassac River, and the lower Mekong. Part of the discharge at Phnom Penh diverted into the Tonle Sap river flows during the early flood season into the huge Tonle

Sap lake. During the period from June to end of September or early October the lake is gradually filled to the level dictated by the hydraulic head between the Mekong and the lake. It has an area of over 6000 km² during the dry season and of up to 16000 km² during extreme floods. The flow into the Tonle Sap lake stops when the two water levels are equal (usually in late September). Then the flow is reversed, the level of the river drops below that of the lake, the lake level starts to fall, and its water discharges into the Mekong, so that a high level of the river flow exists for a long time during the autumn and winter.

Further downstream at Tan Chau the Mekong reaches its maximum usually during the period between September 21 and October 20. In the delta, the floods from Bassac and Mekong are increased again by rainfall convected into the area by tropical storms. In late autumn the Mekong River level decreases rapidly until December, then more slowly from January to March and reaches its minimum level in March or April. Some key data for the hydrology of the Mekong River are given in Table 1.

Since ancient times the Mekong during the summer floods has overflowed its banks between Kompong Cham and Phnom Penh, and further downstream between Phnom Penh and Tan Chau. The flood plain of the delta may be inundated at depths up to many meters, and flood waters not only move laterally through colmatage canals, but some water also moves parallel to the river essentially following the gradient of the land, filling up depressions, - calculations show that the water surface during the peak of extreme floods, such as the 1996 flood, forms roughly a plane inclined towards South over the whole delta. Consequently, areas with low elevations will be deeply flooded, whereas higher ground is inundated only slightly. In particular, the low lying areas near the rivers are deeply inundated. This is a case which occurred also during large recent floods. Examples of such floods are the floods of 1966, 1996, and of 2000. An added problem is that because of the low elevation of the whole delta, the tidal motion of the sea is transferred up the river, and a tidal influence is felt up to Phnom Penh.

People living in the delta have developed a strategy for optimizing the effect of floods. In the course of time the river overflowing its banks on both sides has created natural dikes along its banks, and deposited fertile sediments on the flood plain (see Hori, 2000, for a detailed description). But because the river confined itself through these dikes, the bed of the river in the delta gradually rose, so that the land behind the dikes in many places has an elevation lower than the river. Settlement of the region and agricultural use of the floodplain required some control of the flood path, which was obtained by the introduction of colmatage canals, ideally equipped with inlet and outlet control gates, in the natural (and in places fortified) dikes on the river banks. By means of these canals, water is conducted into the flood plain during floods, and is drained off the flood plain either at the downstream end, or with the receding flood - but not completely, as some water is retained for irrigation.

The conclusion to be drawn from the described situation is that it is virtually impossible to control extreme floods with large peak discharges and long duration by any method of diversion or storing of water. The hope for improving the situation is to prevent early flooding - buying time for harvesting a threatened crop - by providing some limited storage or by increasing local drainage, or with temporary sheltering of areas which could suffer from early flooding. In the Mekong delta floods are prerequisite for agriculture and fisheries. It follows that flood protection and food production (agriculture and fishery) must be seen together. An optimization of flood control therefore is a multi-objective task, and a number of workshops (Al Soufi, 2000, ESCAP, 1999, Herath Dutta, 2000) have been conducted for analyzing the flood problems of the Mekong. Economic development of other kinds is restricted to areas which are high enough to be free from floods. Prerequisite for an efficient management of these tasks is a well functioning early warning system.

STRUCTURE OF AN EARLY WARNING SYSTEM

The components of an early warning system are indicated schematically in Fig.2 (Krysztowicz & Davis, 1983). It consists of a chain of subsystems. The first link is the forecasting system. It consists of a data gathering component, a component for transmission of the data to the forecasting center, and a component of forecast preparation. In the forecasting center, the data are converted into a forecast, which then is transmitted to the decision maker. The decision maker then uses the forecasts to prepare and release a warning, depending on his evaluation. Then the response system is activated. The warning is transferred to the local authorities, who have to take appropriate preventive action and pass the warning on to people in a form so that they can react.

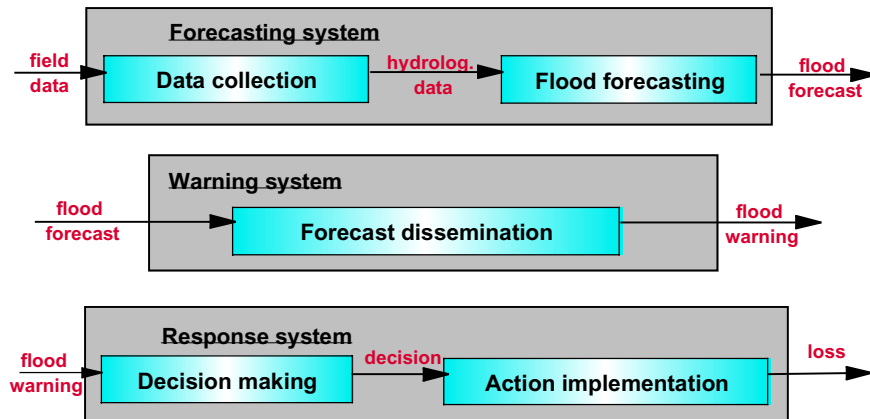


Fig.2: The components of an early warning system (from Krysztowicz & Davis, 1983)

Using the terminology employed by hydrologists, forecasting is the process of estimating in real time the magnitude of an event, i.e. it concerns an event which occurs in the near future. Prediction is the estimation of an event which might occur at some indeterminate time in the future. The difference is illustrated in Fig.3. Consider a forecast made at time $t = t_0$, when the function $Q(t)$ crosses a first critical level h_0 . Based on the information available at time $t = t_0$, the forecast predicts the magnitude of the event as function of time over an interval $t_0, t_0 + T_F$, where T_F is the forecast time.

Forecasting is a process of decision making under uncertainty. Water levels whose course are to be forecasted or predicted, are random time functions. Hydrologists have to work with uncertainty bands which make it impossible to obtain an exact extrapolation of a hydrologic time function, say $Q(t)$. The shorter the forecast time, the more accurate will be the forecast, as is indicated by the uncertainty band in Fig.3. If the forecast time is extended more and more, the condition $T_F = T_p$ is reached where all special information associated with time t_0 is lost, and the forecast can only give the statistical distribution of all possible values of the function $Q(t)$ at any time. The forecast degenerates into a prediction.

Although forecasting and prediction are two ends of the same process, the practical and scientific issues differ significantly. Forecasting requires online actions, based on modelling the near future of the development of the forecasted quantity. The models required are dynamic models for calculating stages, which incorporate the determination of rainfall, the conversion of rainfall into runoff and river stage development. Prediction requires long term records of $Q(t)$ from which reliable statistics can be extracted, and if extreme values are to be predicted, the problem arises of obtaining suitable probability density functions for $Q(t)$ in order to extrapolate from a sample to the population, from the distribution to the extreme val-

ues. The information obtained in the prediction procedure is used to design the warning system, and to draw up hazard maps, in which the magnitude of a potential extreme event and its frequency of occurrence are indicated.

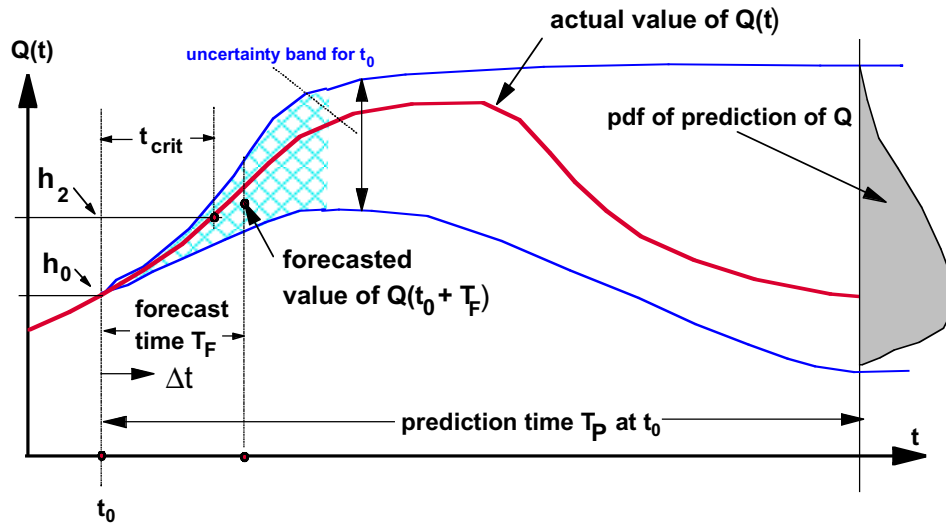


Fig.3: Definition of forecasting and prediction for a random time function

The perfect functioning of a warning system depends on the effectiveness and reliability of all three subsystems. It is absolutely necessary to distinguish between the process of operation of an existing system, and the process of designing and building a warning system. The operation starts with data collection for the forecast, and ending with the response of the people to the warning that is given on the basis of the forecast. It includes not only technical aspects of data gathering, data analysis, forecasting and communication of forecasting results, but it also requires a response that is appropriate to the danger emanating from the forecasted event. As in many other instances, it is one thing to prepare a forecast, but the use of the forecasts is more difficult and depends on many factors. The design of a warning system includes setting up data collection systems, model development and testing, setting up the telemetering network for information commuting, as well as training of both decision makers and public to be able to respond to the warning.

EXISTING EARLY WARNING SYSTEM FOR THE MEKONG

A very large flood in 1966 resulted in the establishment of a flood forecasting program for the Lower Mekong Basin. At the beginning of the 1970's the present central forecasting system was set up. Another push for development of the system was the devastating flood in 1978, when the gage at Pakse recorded water levels 2.5 m higher than normal flood stages, and even higher levels were reached in Cambodia. In the Mekong delta of Viet Nam the Mekong reached the highest level on record. This flood and the next big flood in 1981 led to further improvements of the forecasting system and included major tributaries. The details of the existing forecasting model have been described in Tanaka (1999), and are briefly summarized.

Daily flood forecasts during the months July to October are based on data from 22 rainfall stations and from 37 hydrological stations. These data are transmitted by fixed frequency radio transmission. Meteorological input – rainfall data obtained by ground measurements, weather charts and ground based radar imagery – is used by the Meteorological Service of Thailand for making a rainfall forecast which is used as input into the forecasting model of

the MRC. The rainfall data are adjusted for topographic effects by the flood forecaster of the MRC according to past experience, and daily values are used as direct input for the flood forecasting model. Flood forecasting for the middle reach is based on the model SSARR (Stream-flow Synthesis and Reservoir Regulation) originally developed by the US Corps of Engineers in the sixtieth (US Corps of Engineers, 1975). The watershed model and the streamflow routing part of this modelling package are used in conjunction with a flood routing network developed and calibrated in 1970, and forecasts of water levels are made for 7 to 15 points along the river. Computed discharges are converted into water levels by means of the known stage – discharge (rating) curves.

Daily forecasts for each of the five following days are made. They are made available through the internet and are transmitted to the member countries. The countries then proceed to use the data for the warning procedure in effect in the respective countries. During the 2001 flood season the number of observation stations feeding data into the model has been increased to fifteen key hydrological stations of the mainstream (two in the Lao PDR and five in Thailand, six in Cambodia and two in Viet Nam) and twenty seven rainfall stations (nine in the Lao PDR and eighteen in Thailand). The accuracy of these forecasts of between +/- 10-20 cm is fairly good for a one day ahead forecast, (which, given the large catchment and thus the slow development time for peak flows, is not surprising) but it is not satisfactory for a five day forecast. The present system is being upgraded by MRCS personnel to provide an improved forecast for at least three days.

AN APPROACH FOR IMPROVING EARLY WARNING SYSTEMS

The strategy for flood mitigation in the Lower Mekong Basin (MRCS, 2001, MRC, 2001) called as high priority issue for evaluation and improvement of the flood forecasting and warning system for the Mekong. First task for improving the existing forecasting and warning system is to clearly state the objective of the warning. For the Mekong the two main objectives are: the warning is to prevent or reduce losses from floods, and the warning system should also be used for online scheduling of agricultural activities. The first objective requires warnings against floods of extreme magnitude and duration, early enough so that people can move themselves and their belongings to „safe havens“, i.e. to locations of higher ground which cannot be inundated by the expected flood. The second objective requires forecasting the onset of floods, and in particular the forecast of the beginning of the flood, and of the flood level during the early part of the flood season. A timely warning enables farmers to plan for the harvest of the third crop of rice by using suitable operation rules for the colmatage canals along the lower part of the Mekong and Bassac rivers.

The first step of the evaluation by the experts of the performance of the existing early warning system should result in identifying an ideal system, which would meet the objectives of the warning on the basis of best practice and available technology. The experts were asked to contribute from their knowledge and experience base to the components of each stage of the warning system of Fig.2, using experience with existing models and procedures developed in other countries, and to investigate their applicability for the Mekong. They were given a set of questions specific for their field of expertise. The questions were prepared by the organizer (ourselves and the MRC staff).

The ideal system should be compared with the existing system, and the evaluation should result in a course of action which leads from the existing system to the ideal system. The experts were informed of the existing flood forecasting system by representatives of the MRCS and by representatives of the four member countries of the MRC. Comparison with the ideal system identifies weaknesses of the current system. One problem became immediately apparent. The quality of the early warning system depends on the data base. The large area of the river basin, as well as the very wide mesh of measuring stations currently available re-

stricts the use of systems to those which operate on a limited data base. Therefore, the present system should be upgraded to improve the data base along the river by installing more stations along the main river. This has been recognized by the MRCS, and one of the current projects funded by the Australian Government has this objective. Useful is that in the future the data from the Chinese part of the Mekong will be made available, and further cooperation among Chinese and MRCS forecasters is planned. However, the flood forecasting needs for the Mekong area are not only for the flooding caused by the main river, but also for local flash floods, due to heavy rains, for which the present model is not suitable. As flash floods occur in small areas, their forecast is difficult and depends on much refined meteorological models. It may help, as was pointed out during the expert meeting, to study previous flash flood occurrences. Apparently flash floods occur frequently at the same locations.

It became evident that although the system as it exists is helpful, modern computer technology permits to use more refined and more detailed models, and data availability of meteorological networks has increased as well, as had already been stated by Verwey (1999). Modern technologies of forecasting and their applicability to the Mekong region were discussed (contributions by Barrett, Verdin, Kintenaar, Schultz, all in report MRCS, 2002), based largely on experience gained in the USA, but also experiences from a flood forecasting system for the Limpopo and Zambezi rivers in Mozambik.

The view taken that future meteorological forecasts for the rainfall come from a combination of satellite images and weather forecasts, further improved by using rainfall measurements with ground based radar combined with ground measurements from a somewhat finer meshed grid than the one presently available. These tasks should be performed by the national and international meteorological services, but as these are interested only in weather forecast, for flood warning they have to be converted into useful information for the flood forecast, for which a meteorologist should be available at the forecasting center. He or she should evaluate the cyclone pattern, using information from the regional weather services and from the Typhoon Warning Centers, as the combination of both Monsoon and typhoon is responsible for the rainfall in the region. The different possibilities that exist for a remote weather forecasts were listed by Schultz (in MRC 2002, see also Schultz, 1996), but obviously, the use of satellite and radar pictures is restricted by the capabilities of the staff and the availability of affordable images.

The rainfall is to be converted into effective rainfall by means of a soil moisture model – in the simple case, by assigning a runoff coefficient to each partial area, in the most complex case by using a soil moisture model for each of the contributing areas for the catchment. As was demonstrated by some of the experts, newer models that have reached high maturity are available (Meon, Todini, in MRCS, 2002, see also Todini, 1996) which should be considered for adaptation – in fact, an important task is to intensively review existing models and to identify those that have the most suitable amount of detail, as is needed for the Mekong. Different hydraulic models need to be used for flood stage forecasting for large rivers such as the lower part of the Mekong, and for forecasting systems for smaller catchments, i.e. the catchments of the tributaries of the Mekong. Typical hydraulic models were discussed (Schultz, Todini, Meon, Tsinganshali, in MRCS 2002) that have been used successfully in different parts of the world. They are complemented by a discussion of the role of sediment deposition in the lower reaches of the Mekong (Wu, in MRCS 2002)

Clearly, a compromise between the amount of detail in the model (and the amount of data needed for using such models) and the effort that can be made for the forecast has to be made, thereby accounting for the available data base – now and in the future. This part of the rainfall runoff model is perhaps as important as hydraulic modeling of the flow in the river. However, hydraulic modeling is needed for forecasting stages. The conversion the output from rainfall – runoff model into discharges and stages is introducing large errors, in particular as the stage discharge relationships for a natural channel are very difficult to determine analyti-

cally, and are also subject to change due to the movement of sediment, which may change the channel geometry of Mekong and tributaries.

Usually, some type of warning system exists – even without technology, people can infer flood dangers to a certain extent from past experience, and in the case of the Mekong Basin, the system described above is in place. Scientists and engineers now must identify the best feasible ways of going from the existing to the ideal system and determine costs and benefits. By a decision of the authorities (the decision maker) the sequence of steps for implementing the system or system components is prioritized. First improvements with highest effect on saving human lives or having the highest benefit – cost ratio for property damage reduction should be developed. The final steps consist of detailed planning, construction, and operation of the system.

The development and construction of a flood forecasting and warning system is not sufficient to guarantee a good warning. The flood forecast must be transferred to the people at risk through a chain of actions starting with a conversion of the forecast into warning by a decision process involving different stages, and finally, the warning has to be converted into appropriate action by local authorities and the people at risk themselves. The performance of an early warning system must be measured on how effective these actions are: a warning that is too late for response is useless. The forecasts must be an integrated part of a complete warning system. We have to identify the path of the warning from the forecast to the persons responsible for decision making for flood protection actions. This is an aspect that has been little covered in the literature, and the experiences of administrators in different parts of the world are called for, and are to be compared with the experience of local administrators. Some considerable experience has been gained for the Rhine river in Germany, (as expounded by Rother, in MRCS 2002) and for the Oder river on the border of Germany and Poland (Kundzewicz, in MRCS 2001) and the interests of all riparian countries have to be integrated into a compromise plan which guarantees maximum flood protection for all people in the region.

The last part is the conversion of warnings into reactions of the people who obtain the warning. How is the warning used for different purposes, and which methods can be used to help, or to give people the means and the information to help themselves. Social scientists (Kraas, and Affeltranger, in MRCS, 2002) reviewed local persons and non-governmental organizations with considerable experience and identified weak points in the structure of information transfer to the people - experiences which cannot directly translated into engineering solutions, but which are invaluable for local decision making.

The major conclusions were based on the task of seeing the early warning as a holistic problem, in which all components of the chain of actions had equal weight –the emphasis on forecasting being important, but other more neglected aspects needing more attention in the future. This includes first of all a strengthening of the staff at all levels: to be able to handle flood forecasting and warning, to build up competence and experience, and last not least, to increase the institutional memory. Good meteorology requires good meteorologists, who can evaluate the information provided from forecasts of weather and climate by forecasting services such as the Thai Meteorological Service, the Global Numerical Meteorological Climate and the partner organizations of the ESCAP Typhoon Committee. By having discussed these four stages of the early warning process both from the point of view of designing an ideal system and operating the existing system we hope to have helped the Mekong River Countries and the Mekong River Commission to obtain an effective warning system, and by looking at the requirements for the warning system, we also may make a contribution towards the objective of obtaining a flood protection system which helps to prevent the large damages and losses of lives that are not uncommon under present conditions.

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